Alice Lorraine Smith Microbiology and Pathology

ELEVENTH EDITION

Microbiology and Pathology

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with 564 illustrations, including 2 color plates

ELEVENTH EDITION



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То

Frederick and Ned

Preface

I keep six honest serving-men (They taught me all I knew); Their names are What and Why and When And How and Where and Who.

RUDYARD KIPLING

The scientific answers to the What and When and How and Who are coming so thick and fast in these exciting days that to no one's surprise it is time for a revision of *Microbiology and Pathology*. Here then is the book reworked to give contemporary coverage in sister subjects of major importance and designed to be readily assimilated by students in health science training programs.

The unit scheme of prior editions continues, with six units for microbiology and two for pathology. In microbiology the unit pattern is in biologic orbit around microorganisms. It begins with basic concepts in the first unit, includes laboratory methods in the second, and in subsequent units develops the events of injury, indicts culprits, and emphasizes restraints.

What happens when microbes and their products contact living cells of the human body is a theme permeating this book. One full unit (Unit III) is devoted to it. This unit concentrates on defenses inherent in the body, the immune system, immunopathology, allergy, and key laboratory reactions in immunology. (Tumor immunology is reserved for the chapter on neoplasms.)

A small and fairly compact unit categorizes various agents destroying or impeding microbes. The action of antibiotics is noted, and unfavorable side effects of antibiotic administration are stressed. Technics for sterilization are compared; for example, gas sterilization with steam sterilization.

The largest unit of the book makes up the roster of significant pathogens and parasites, stressing their identity and the nature of their injury. Material pertinent to the pathology and pathogenesis of a given infection is placed in the chapter considering the causative agent. The overall pathology of infectious

disease is found at the end of the chapter on inflammation.

An unusual unit, the last one for microbiology, relates the student to the microbial life of our environment. A survey, yet a practical unit, it accommodates such items as measures to safeguard food and swimming pool sanitation. Herein two chapters are paired to focus on the best available information on immunization from the United States Public Health Service, the American Academy of Pediatrics, the United States Armed Forces, and the World Health Organization (WHO). The companion chapters sort out modern biologic products, outline technics in passive immunization, tabulate latest schedules for active immunization, and give crucial guidelines for administration of biologic products.

The second part of the book bisects pathology in traditional fashion. General pathology is the overview of fundamentals to disease anywhere in the body. Special pathology fits these to major anatomic areas. Wherever possible, the changes in body fluids demonstrable in the clinical laboratory are correlated with pathologic findings in tissues.

This book in frame and substance must remain relevant to the here and now in health careers. It has been edited and updated to keep it so. There are new topics and new emphases. Topics expanded include the biologic classification of microbes, the lymphoid system's role in immunity, anaerobes in disease, concepts of immunopathology, immunologic reactions, viral hepatitis, endotoxin shock, chemical carcinogenesis, and viral oncogens. Subjects new to this edition include the serologic diagnosis of protozoan and metazoan diseases, experimental production of dental caries, practical technics to evaluate cell-mediated immunity, the scanning electron microscope, early detection of breast cancer, immunotherapy, postnecrotic cirrhosis, fetal antigens, and the Dane particle.

The classification of bacteria throughout this text is that of Bergey's Manual of Determinative Bac-

teriology (1974), with the notable exception of the arrangement of enteric bacteria according to the scheme of W. H. Ewing. For viruses, not included in the eighth edition of Bergey's Manual, the most modern classification is still that based on their properties. The revisions in the new Bergey's Manual necessitated considerable reorganization and changes in terminology. Note that rickettsias, chlamydiae (bedsoniae), and actinomycetes are now bacteria.

The illustrations have been selected to enrich the meaning of the prose. For instance, when the subject of tuberculin testing is presented, the photograph of positive skin reactions makes the impact. The first of two color plates highlights the different approaches to the laboratory study of microbes, and the second presents changes in blood cells with leukemia. Every teacher knows that tables dramatize and give quick access to information. Immunization schedules, sterilization maneuvers, incubation periods, comparative sizes, coagulation factors, metric equivalents, classification of neoplasms, coagulation sequence (the "waterfall"), mechanisms of edema, comparison of comparable diseases, differential characteristics, and biologic properties can thus be arranged effectively.

Current references are gathered at the end of a unit or after closely related chapters. Thought-provoking questions for review occupy the usual place at the end of the chapter. Sources for the glossary are found in the text, standard medical dictionaries, and Webster's unabridged dictionary.

This revision would not have been possible without the counsel, technical know-how, and cooperation of certain talented persons at The University of Texas Health Science Center at Dallas. In the Department of Pathology, I gratefully acknowledge the kindness of Dr. V. A. Stembridge, Chairman, Drs. R. C. Reynolds, B. D. Fallis, Frank Vellios, professors, Dr. C. S. Petty. Chief Medical Examiner for Dallas County and Professor of Forensic Sciences and Pathology, Mrs. Phyllis Kitterman, Secretary, Mrs. Linda Bolding, Laboratory Technical Assistant, and Mr. Donald Calhoun, photographer for the Medical Examiner's office: in the Department of Medical Illustration Services, Dr. W. R. Christensen, Chairman, R. J. Castanie, medical illustrator, and Miss Jean Gionas. medical photographer; and in the Library, Mrs. Elinor Reinmiller, Reference Librarian, and other able members of Dr. Donald Hendricks's staff. I am indebted to Mrs. Earline Kutscher, Chief Technologist, and her staff at the Bacteriology Laboratory of Parkland Memorial Hospital for invaluable assistance.

Now a special word of appreciation to teachers and students whose ever-welcome criticisms and comments have guided me: may I voice a heartfelt thanks to the many of you who have used this text and who carefully consider the new edition.

Alice Lorraine Smith

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Part one MICROBIOLOGY

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UNIT II

Microbes: procedures for study

UNIT III

Microbes: production of infection

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Microbes: preclusion of disease

UNIT V

Microbes: pathogens and parasites

UNIT VI

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UNIT I

MICROBIOLOGY prelude and primer

CHAPTER 1

Definition and dimension

Take interest, I implore you, in those sacred dwellings which one designates by the expressive term: laboratories. Demand that they be multiplied, that they be adorned. These are the temples of the future—temples of well-being and of happiness. There it is that humanity grows greater, stronger, better.

LOUIS PASTEUR

Definition

Biology is the science that treats of living organisms. The branch of biology dealing with *microbes*—that is, organisms structured as one cell and studied with the microscope—is *microbiology* ("microbe-biology"). Microbiology considers the occurrence in nature of the microscopic forms of life, their reproduction and physiology, their participation in the processes of nature, their helpful or harmful relationships with other living things, and their significance in science and industry.

Within the province of microbiology lies the study of bacteria, viruses, fungi, and protozoa. Subordinate sciences are *bacteriology*, the study of bacteria; *virology*, the study of viruses; *mycology*, the study of fungi (unicellular and multicellular plants); and *protozoology*, the study of protozoa (unicellular animals). Many microbes are parasitic. The science dealing with organisms dependent on living things for their sustenance is *parasitology*. So closely associated with microbiology as to be considered a part of it is the science of *immunology*, the study of those mechanisms whereby one organism deals with the harmful effects of another.

Although man has lived with microorganisms from time immemorial and has used certain of their activities, such as fermentation, to his advantage, the science of microbiology is a product of only the last hundred years or so. The studies of Antonj van Leeuwenhoek in the seventeenth century had shown the existence of microscopic forms of life, but it was not until the work of Louis Pasteur toward the end of the nineteenth century (some 200 years later) that the science of microbiology really took shape. The new science stated the germ theory of disease, demon-

strated patterns of communicable disease, and gave man a measure of protection he had not known in his struggle against the injurious forces in the biologic environment.* In its time this very young science has influenced practically every type of human endeavor.

Dimension BIOLOGIC CLASSIFICATION

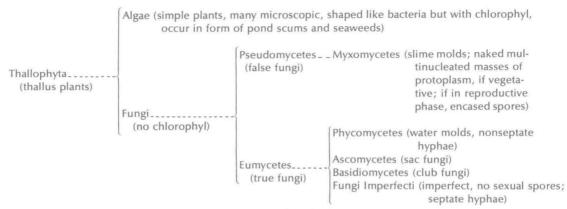
All living things are classified in a scheme of categories with breakdown into successively dependent and related groups. The highest possible levels are designated kingdoms, of which there may be two or three. For years, the traditional two were the plant and animal kingdoms. Today there are forces for change in this approach. The following terms are basic ones in classification and are listed in ascending order:

- Species—organisms sharing a set of biologic traits and reproducing only their exact kind
 - a. Strain—organisms within the species varying in a given quality
 - b. Type—organisms within the species varying immunologically
- 2. Genus (pl., genera)—closely related species
- 3. Family—closely related genera
- 4. Order—closely related families
- 5. Class—closely related orders
- 6. Phylum (pl., phyla)†—related classes

The lower forms of life incorporate variably features of both plants and animals and do not show the dramatic differences of the higher forms. It is difficult to define many microbes as either plant or animal,

^{*}For scientific knowledge to bring results, such as in the organization of public health programs, it must be disseminated. Such is the purpose of *health education*. To the individual it explains the mechanisms by which he can protect himself against microbial hazards. To the social group it designates the available community resources.

[†]In plant biology, the term *division* is used instead of phylum. In Table 1-1 (p. 5), note use of the term *division* for either of the two major classifications in the kingdom to include all procaryotes.



Schema 1, Subdivisions of Thallophyta. See also p. 326.

and as bacteria and other microbes long classified as plants have been more closely studied, the inconsistencies appear even greater. Because of this fact, a third major biological compartment with equivalent rank to the plant and animal kingdoms has been advocated to sift out the simpler units, designating them as *protists*. Basically most protists are one-cell units and remain so throughout their life history. Even if they pile cells up in large plantlike masses, their component cells remain the same and do not differentiate.

There is an alternate scheme of classification of living things, again based on complexity of structure but this time focused directly on the nucleus. It is apparent that "higher" organisms possess a true nucleus; "lower" ones do not. Thus two distinct categories emerge. The obvious nucleus in the higher forms' is complete, with the expected number of chromosomes and mitotic apparatus. These organisms are termed "eucaryotic" (using the Greek word which means true nucleus). This category (or kingdom) would be one to contain some protists and the plants and animals.

In the lower forms of life, nuclear function is carried out by only a single chromosome, devoid of any membrane. Lower forms are small and less complex in other ways. For instance they do not contain such membrane-bounded organelles as mitochondria. They are designated "procaryotic," the second category to encompass all bacteria and a small group of blue-green algae (algae demonstrate plantlike photosynthesis).

Procaryotes, as a grouping, share distinctive properties. They possess certain unique components in their cell walls, and they display remarkable capabilities with regard to carbon storage, nitrogen fixation, obligate anaerobiosis, and derivation of energy from oxidation of inorganic compounds.

Scope. Microorganisms usually surveyed in a treatise of microbiology include bacteria (unicellular

procaryotes as indicated above), fungi, and lower forms of animal life.

Fungi are best known as plants and are gathered into Thallophyta, one of the four divisions of the plant kingdom. Thallophytes, or thallus plants (Greek, thallos, young shoot or branch), are defined as simple forms of plant life that do not differentiate into true roots, stems, or leaves. The term fungi as ordinarily used refers to molds, yeasts, and certain related microorganisms. Schema 1 gives the subdivisions of thallus plants.

Some of the most important disease-producing agents known to man are lower forms of animal life. They include the unicellular protozoa, the simplest ones, and a restricted number of the more complex multicellular or metazoan animals as well (Chapters 31 and 32).

NAMING OF MICROBES

The scientific name of a living organism is usually made up of two words that are Latin or Greek in form. The first name begins with a capital letter and denotes the genus. The second name begins with a small letter and denotes the species. Either the genus or the species name may be derived from the proper name of a person or place or from a term describing some feature of the organism. The proper name may be that of the scientific investigator or that of the related geographic area. Biologic characteristics indicated include color, location in nature, disease produced, and presence of certain enzymes. For example, Staphylococcus aureus is the scientific name for bacteria of genus Staphylococcus (Greek, staphyle, bunch of grapes + kokkus, berry) and species aureus (Latin, aureus, golden). It indicates that the bacteria grow in typical clusters and produce a golden pigment. Honoring Sir David Bruce who discovered it, Brucella melitensis (pertaining to the island of Malta) by its name indicates its disease-Malta fever, or undulant

Table 1-1

Abbreviated classification of microbes from Bergey's Manual of Determinative Bacteriology (1974)*

Kingdom *Procaryotae* † (highest level taxon encompassing microbes in which nucleoplasm lacks basic protein and is not bounded by nuclear membrane)

Division I. The Cyanobacteria (blue-green algae with gliding motility, producing oxygen in light; photosynthetic procaryotes as single cells or simple or branched chains of cells; photopigments include chlorophyll a)

Division II. The Bacteria (unicellular procaryotes multiplying by growth and division, usually binary; if cells remain together, arrangement classical; true branching may be seen; motility from flagella or by gliding, twitching, snapping, or darting motions; majority encased in rigid cell wall [constancy of form], most of which contain peptidoglycans; photosynthesis, if carried out, is anaerobic and bacteriochlorophylls used; chemosynthesis requires aerobic or anaerobic conditions, with some microbes facultative; endospores formed in some species, arthrospores and cysts in others, but no heterocysts)

PART 1 PHOTOTROPHIC BACTERIA!

Order I. Rhodospirillales (mostly water bacteria; gram-negative, variably shaped, all with bacteriochlorophylls and carotenoid pigments; purple-violet, purple, red, or orange-brown, brown, or green colors from photopigments in cell suspensions; some can fix nitrogen; purple [sulfur or nonsulfur] and green sulfur groups of bacteria here)

PART 2 GLIDING BACTERIA

Order I. Myxobacterales (slime bacteria; gram-negative, strict aerobes with slow gliding movements found on soil and decomposing plant and animal matter; no photosynthetic pigments; chemoorganotrophs; energy-yielding mechanism respiratory, never fermentative; fruiting bodies formed from cell aggregates often brightly colored and macroscopic; bacteriolytic and cellulytic [attacking cellulose] groups here)

Order II. Cytophagales (rods or filaments, gram-negative, with slow or rapid gliding; no fruiting bodies; chemolithotrophs, chemogranotrophs, or mixotrophs)

PART 3 SHEATHED BACTERIA

(sheath present may be encrusted with iron or manganese oxides; single cells; flagella may be found)

Genus Leptothrix (gram-negative, strictly aerobic straight rods in chains within a sheath; also free-swimming as single cells, in pairs, or in motile short chains; sheaths often impregnated with hydrated ferric or manganic oxides; prevalent in iron-containing, uncontaminated, slow-running fresh waters)

Genus Streptothrix (thin, gram-negative rods in chains; strictly aerobic; widely distributed in fresh water and in activated sludge; barely visible sheaths not encrusted)

PART 4 BUDDING AND/OR APPENDAGED BACTERIA

(soil and water bacteria reproducing by budding; may have excreted appendages and holdfasts; in some a semi-rigid appendage, the prostheca, proceeds out from the cell, like the stalk of *Caulobacter* genus, extending the length of the rod, a small bit of glue at its tip)

PART 5 SPIROCHETES

Order I. Spirochaetales

Family I. Spirochaetaceae

Genus I. Spirochaeta (motile spirals in helical form, free-living in H₂S-containing mud and sewage)

Genus II. Cristispira (spirals with 2 to 10 complete turns; commensal in mollusks)

Genus III. Treponema

Treponema pallidum (syphilis)

Treponema pertenue (yaws)

Treponema carateum (pinta, a chronic skin disease of children endemic in South and Central America)

Treponema denticola [microdentium]

Treponema [Borrelia] vincentii

Species incertae sedis: Treponema buccale [Borrelia buccalis]

Genus IV. Borrelia

Borrelia recurrentis (louse-borne epidemic relapsing fever)

Borrelia species (tick-borne endemic relapsing fever)

Genus V. Leptospira

Leptospira interrogans [icterohaemorrhagiae] (leptospirosis)

Continued.

^{*}Based on data from Buchanan, R. E., and Gibbons, N. E., co-editors: Bergey's manual of determinative bacteriology, ed. 8, Baltimore, 1974, The Williams & Wilkins Co.

[†] Eucaryotae, the corresponding taxon at the same level, includes other protists and the plants and animals.

[†]Phototrophic or photosynthetic.

Table 1-1

Abbreviated classification of microbes from Bergey's Manual of Determinative Bacteriology (1974)—cont'd

PART 6 SPIRAL AND CURVED BACTERIA

Family I. Spirillaceae

Genus I. Spirillum

Spirillum minor (one type of rat-bite fever in man)

Genus II. Campylobacter (slender spiral rods found in reproductive and alimentary tracts of man and animals; some species pathogenic)

Campylobacter [Vibrio] fetus (abortion in sheep and cattle, infections in man)

PART 7 GRAM-NEGATIVE AEROBIC RODS AND COCCI

Family I. Pseudomonadaceae

Genus I. Pseudomonas

Pseudomonas aeruginosa (wound, burn, and urinary tract infections)

Pseudomonas [Actinobacillus] mallei (glanders and farcy in horses and donkeys; infection transmissible to man)
Pseudomonas pseudomallei (human and animal melioidosis)

Genus II. Xanthomonas (plant pathogens)

Genus III. Zoogloea (motile, gram-negative rods in natural waters and sewage)

Genus IV. Gluconobacter (ellipsoids or rods in flowers, souring fruits, vegetables, cider, wine, baker's yeast, garden soil: ropiness in beer and wort)

Family II. Azotobacteraceae (large, motile, aerobic gram-negative rods fixing atmospheric nitrogen; found in soil and water and on leaf surfaces)

Genus I. Azotobacter (nitrogen fixation)

Genus II. Azomonas (nitrogen fixation)

Genus III. Beijerinckia (nitrogen fixation)

Genus IV. Derxia (found in tropical soils of Asia, Africa, South America; fixation of atmospheric nitrogen)

Family III. Rhizobiaceae (nitrogen fixation—symbionts in root nodules of legumes; cortical overgrowths in plants)

Genus I. Rhizobium (nitrogen fixation)

Genus II. Agrobacterium (plant pathogens—tumorigenic phytopathogens; hypertrophies [galls] on stems of more than 40 plants; free nitrogen not fixed; found in soil)

Family IV. Methylomonadaceae (gram-negative bacteria using only one-carbon organic compounds, e.g., methane and methanol, as carbon source)

Family V. *Halobacteriaceae* (high concentration of sodium chloride necessary for growth; found in salterns, salt lakes, Dead Sea, proteinaceous material preserved with solar salt, e.g., fish, sausage casings, and hides)

Genus I. Halobacterium (salt-living rods)

Genus II. Halococcus (halophilic cocci; red colonies)

Genera of uncertain affiliation

Genus Alcaligenes [Achromobacter] (motile, aerobic rods or cocci; common saprophytes in intestines of vertebrates, in dairy products, rotting eggs, fresh water, soil; important in decomposition and mineralization processes)

Alcaligenes faecalis (type species; some strains denitrify)

Genus Acetobacter (motile, aerobic vinegar rods; oxidize ethanol to acetic acid; found on fruits and vegetables, in souring fruit juices, vinegar, alcoholic beverages)

Acetobacter aceti (acetic acid bacterium)

Genus Brucella (brucellosis)

Brucella melitensis (Malta fever; infection in goats, sheep, and cattle)

Brucella abortus (abortion in cattle; disease in man)

Brucella suis (usually attacks pigs; also pathogenic for other animals, man)

Genus Bordetella

Bordetella pertussis (whooping cough)

Bordetella parapertussis (whooping cough)

Bordetella bronchiseptica (found in respiratory tract of animals, sometimes man; rodent bronchopneumonia)

Genus Francisella

Francisella [Pasteurella] tularensis (tularemia)

Francisella novicida (experimental pathogen)

Genus *Thermus* (gram-negative, nonmotile rods and filaments; often pigmented; common in hot springs, hot water tanks, and thermally polluted rivers; unusually thermostable enzymes, ribosomes, plasma membrane)

PART 8 GRAM-NEGATIVE FACULTATIVELY ANAEROBIC RODS

Family I. Enterobacteriaceae

Genus I. Escherichia

Escherichia coli (type species; the colon bacillus; important opportunistic pathogen)

Genus II. Edwardsiella

Edwardsiella tarda (type species)

Genus III. Citrobacter

Citrobacter freundii (type species)

Genus IV. Salmonella (salmonellosis)

Subgenus I

Salmonella cholerae-suis (type species; salmonellosis)

Salmonella hirschfeldii (paratyphoid C bacillus; enteritis)

Salmonella typhi (typhoid fever)

Salmonella paratyphi-A (paratyphoid [enteric] fever)

Salmonella schottmuelleri (enteritis)

Salmonella typhimurium (food-poisoning in man)

Salmonella enteritidis (enteritis)

Salmonella gallinarum (fowl typhoid)

Subgenus II

Salmonella salamae

Subgenus III

Salmonella arizonae (isolated from reptiles)

Subgenus IV

Salmonella houtenae

Genus V. Shigella (shigellosis)

Shigella dysenteriae (type species; bacillary dysentery plus effects of diffusible neurotoxin)

Shigella flexneri (bacillary dysentery)

Shigella boydii (bacillary dysentery)

Shigella sonnei (one cause of summer diarrhea in young children; milder form of bacillary dysentery in adults)

Genus VI. Klebsiella

Klebsiella pneumoniae (type species; pneumonia, infections of respiratory and urinary tracts)

Klebsiella ozaenae (found in ozena and chronic respiratory disease)

Klebsiella rhinoscleromatis (found in rhinoscleroma, a granulomatous disorder of nose and pharynx associated with nodular induration of tissues)

Genus VII. Enterobacter

Enterobacter cloacae (type species)

Enterobacter [Aerobacter] aerogenes

Genus VIII. Hafnia (Hafnia, the old name for Copenhagen)

Genus IX. Serratia

Serratia marcescens (type species)

Genus X. Proteus (urinary tract infections, community and hospital-acquired)

Proteus vulgaris (type species; urinary tract and wound infections, rarely peritonitis, meningitis)

Proteus mirabilis (most commonly encountered species in clinical specimens)

Proteus morganii (one cause of summer diarrhea in infants)

Proteus rettgeri (gastroenteritis)

Proteus [Providencia] inconstans (urinary tract infections)

Genus XI. Yersinia

Yersinia [Pasteurella] pestis (plague)

Yersinia [Pasteurella] pseudotuberculosis (pseudotuberculosis in animals—usually mesenteric lymphadenitis; septicemia in man)

Yersinia enterocolitica (widespread; been found in sick and healthy animals and in material likely contaminated by their feces; enterocolitis in young children, mesenteric lymphadenitis, variety of other infections)

Genus XII. Erwinia (plant pathogens)

Continued.

Table 1-1

Abbreviated classification of microbes from Bergey's Manual of Determinative Bacteriology (1974)—cont'd

PART 8 GRAM-NEGATIVE FACULTATIVELY ANAEROBIC RODS-cont'd

Family II. Vibrionaceae

Genus I. Vibrio

Vibrio cholerae [comma] (type species; cholera)

Vibrio cholerae biotype eltor (El Tor vibrio; cholera)

Vibrio parahaemolyticus (acute gastroenteritis)

Vibrio [Photobacterium] fischeri (luminescent saltwater bacteria)

Genus II. Aeromonas (motile gas-forming rods)

Aeromonas hydrophila (type species; nonluminescent freshwater bacteria; infections of cold-blooded animals—red leg [bacteremia] in frogs and septicemia in snakes—and, rarely, infections in compromised host)

Genus III. Plesiomonas (motile rods growing mostly on mineral media containing ammonia as sole source of nitrogen and glucose as sole source of carbon; found in feces; infectious gastroenteritis reported in man)

Genus IV. Photobacterium (luminescent saltwater bacteria)

Genus V. Lucibacterium (light-emitting bacteria; luminescent saltwater bacilli; found on surfaces of dead fish) Genera of uncertain affiliation

Genus Chromobacterium (soil and water bacteria producing violet pigment violacein; infections in animals; food spoilage)

Genus Flavobacterium (proteolytic soil and water bacteria producing yellow, orange, or red pigments; found on vegetables and in dairy products; rare infection in man by unpigmented organism)

Genus Haemophilus

Haemophilus influenzae (purulent meningitis in young children; acute respiratory infection; acute conjunctivitis)

Haemophilus suis (with virus, causes swine influenza)

Haemophilus haemolyticus (commensal in upper respiratory tract of man)

Haemophilus parainfluenzae (found in upper respiratory tract of man and cats)

Haemophilus parahemolyticus (found in upper respiratory tract of man; associated with acute pharyngitis in man; pleuropneumonia and septicemia in swine)

Haemophilus aphrophilus (endocarditis and other infections in man)

Haemophilus ducreyi (chancroid)

Species incertae sedis

Haemophilus aegyptius (Koch-Weeks bacillus; acute infectious conjunctivitis)

Haemophilus vaginalis (gram-variable bacilli and coccobacilli, showing metachromatic granules and arranged like Corynebacterium, found in human genital tract; nonspecific vaginitis and urethritis)

Genus Pasteurella

Pasteurella multocida (type species; chicken cholera; shipping fever of cattle; hemorrhagic septicemia in warm-blooded animals; in cat- and dog-bite wound infections)

Pasteurella pneumotropica (infections in animals; dog-bite wounds in man)

Pasteurella haemolytica (enzootic pneumonia of sheep and cattle; septicemia of lambs)

Genus Actinobacillus (actinobacillosis)

Actinobacillus lignieresii (actinobacillosis of cattle [wooden tongue] and of sheep)

Actinobacillus equuli (actinobacillosis in horses and pigs)

Genus Cardiobacterium

Cardiobacterium hominis (type species; found in human nose and throat; endocarditis in man)

Genus Streptobacillus [Haverhillia] (rods and filaments in chains, with filaments showing bulbous swellings, like a string of beads; parasites and pathogens of rats and other mammals)

Streptobacillus moniliformis [Actinomyces muris-ratti] (type species; necklace-shaped bacteria found in nasopharynx of rats; streptobacillary rat-bite fever)

Genus Calymmatobacterium (pleomorphic encapsulated rods like safety pins)

Calymmatobacterium [Donovania] granulomatis (granuloma inguinale)

PART 9 GRAM-NEGATIVE ANAEROBIC BACTERIA

Family I. Bacteroidaceae

Genus I. Bacteroides (bacteroidosis)

Bacteroides fragilis (type species; opportunist in visceral and wound infections; most common anaerobe in soft tissue infections)

Bacteroides oralis (gingival crevice of man; oral, upper respiratory, and genital infections)

Bacteroides [Eikenella] corrodens (part of normal flora of man and animals; opportunist in infections of respiratory and alimentary tracts)